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FINAL REPORT ON THE ENVIRONMENTAL TEST PROGRAM FOR THE ATMOSPHERE EXPLORER-B SPACECRAFT

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Goddard Space Flight Center
Greenbelt, Maryland

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N67-13166

ABSTRACT

The AE-B spacecraft was launched May 25, 1966, from the Eastern Test Range (ETR) aboard a DSV-3c Delta launch vehicle (no. 38). Upon achieving orbit the spacecraft was renamed Explorer 32. Except for failures in the neutral particle mass spectrometer experiment and in the tape recorder, Explorer 32 continues to function well.

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1. INTRODUCTION

The purpose of this report is to document the significant events of the Atmosphere Explorer-B environmental test program and subsequent events which may have affected the test program results. Included in the program were tests on the prototype and flight spare subassemblies, various shell models, and the flight spacecraft. A summary of spacecraft operations at the Eastern Test Range (ETR) is included as well as a brief discussion and evaluation of the spacecraft orbital performance.

2. SUBASSEMBLY TESTING

AE-B subassembly testing began in May 1964, and was completed in September 1966. During this period, 135 subassemblies were tested, 52 prototype subassemblies, and 83 flight and flight spare subassemblies. The environmental tests conducted were primarily of the vibration type with occasional temperature, thermal-vacuum, and acceleration tests. Generally, flight spacecraft subassemblies were not subjected to environmental tests prior to integration in the spacecraft.

2.1 Subassembly test specification

The environmental test specification for AE-B subassemblies is contained in a document entitled "Environmental Test Specifications for S-6A Subassemblies," dated November 7, 1963.

2.2 Prototype subassemblies

Table I lists the prototype subassemblies tested, type of test, test dates, and test results.

Table I
AE-B Prototype Subassembly Tests

Item	Test	Date	Satisfactory or Unsatisfactory
1. Three pressure gage break-off mechanisms.	Vibration th-vacuum	5/12/64 5/13-14/64	S S
2. Cold cathode gage converter, serial no. 2.	Vibration	6/8-9/64	S
3. Eng. model ion mass spectrometer.	Vibration	7/14-16/64	S
4. Command receiver, decoder, and tracking transmitter.	Vibration	8/5/64	S
5. Magnetic attitude and spin rate control electronics, serial no. 1. Card has since been modified with no retesting.	Vibration (Conducted at APL)	9/2/64	S
6. Mass spectrometer logic electronics.	Vibration	11/23/64	S
7. Eng. model leak valve. Not the type being used in spacecraft.	Vibration	11/24/64	S
8. Structural model GCA pressure Gage.	Vibration	12/3/64	S
9. Electron temperature probe boss with probe.	Vibration	12/8/64	S
10. Relay module.	Vibration	12/8/64	S
11. Amphenol connector.	Vibration	12/8/64	S
12. Safety monitor module.	Vibration	12/9/64	S
13. Thermistor power supply.	Vibration	12/9/64	S
14. Altitude pressure switch, serial no. 1.	Vibration th-vacuum	12/21/64 1/5-6/65	S S
15. Eng. model fuel cell. Cell leaked small quantity of potassium hydroxide during acceleration test.	Vibration acceleration	12/21/64 12/30/64	S U
16. Prototype fuel cell.	Acceleration vibration	1/26/65 1/28/65	S S
17. Multiplexer, serial no. 11.	Vibration acceleration	2/2/65 2/8/65	S S
18. Pressure relief valve.	Vibration	2/3/65	S
19. Ion mass spectrometer ceramic tube. Tube leaked slightly after test. Mounting bolts were loosened during the test and probably caused a more severe test.	Vibration	2/4/65	U
20. Ion mass spectrometer electronics, serial no. 1	Vibration	2/23/65	S
21. Ion mass spectrometer; during the first test, a small wire broke at the connection.	Vibration	2/24/65	U
22. Ion mass spectrometer; during the second test, a resistor failed, and a small wire connection broke.	Vibration	2/25/65	U
23. Ion mass spectrometer; during the third test, a small wire broke.	Vibration	2/26/65	U

Table I (Continued)
AE-B Prototype Subassembly Tests

Item	Test	Date	Satisfactory or Unsatisfactory
24. Ion mass spectrometer; during the fourth test, a small wire broke at the soldered connection.	Vibration	3/3/65	U
25. Ion mass spectrometer, fifth test.	Vibration	3/8-9/65	S
26. Eng. model telemetry transmitter.	Vibration	3/16/65	S
27. Optical aspect converter, serial no. 01.	Vibration	3/25/65	S
28. Telemetry transmitter no. 10X17.	Vibration	4/6/65	S
29. Pressure check valve	Vibration	4/9/65	S
30. Mass spectrometer hat was partially tested. Ceramic seal apparently broke while remounting the hat on the fixture. No test conducted.	Vibration	4/16/65	NT
31. Mass spectrometer hat.	Vibration	4/17/65	S
32. Five eng. model pressure gage break-off mechanisms. Separation tests were successful although a redundant squib in one unit failed.	Vibration	5/4/65	S
33. Eng. model pressure relief valve (explosive type).	Vibration	5/18/65	S
34. Five pressure gage break-off mechanisms.	Vibration Th. vacuum	6/9/65 6/9-10/65	S S
35. Telemetry encoder	Vibration	6/16/65	S
36. AC roll amplifier, no. 102.	Vibration	8/23/65	S
37. Tape recorder, F.U. no. 1, prototype and flight spare.	Vibration	8/26/65	S
38. N.P. mass spectrometer tube no. 18 with break-off cover - no magnet. Silver oxide coating successfully completed the test, but a small metal shield between collector buckets fatigued and broke which prevented running the final random test.	Vibration	9/8/65	S
39. N.P. mass spectrometer logic electronics, prototype, post-launch test.	Vibration	6/7/66	S
40. Tape recorder with converter and motor driver, prototype, and flight spare post-launch test	Temperature	9/6-16/66	S

Table II
AE-B Flight and Flight-Spare Subassembly Tests

Item	Test	Date	Satisfactory or Unsatisfactory
1. Electron temperature probe, flight.	Vibration	12/21/64	S
2. Multiplexer, serial no. 9, flight spare.	Vibration	2/4/65	S
3. Turn-on counter, F-2, flight spare	Vibration temperature	3/25/65 3/29-4/3/65	S S
4. Thermistor power supply, F-2, flight spare	Vibration temperature	3/25/65 3/29-4/3/65	S S
5. Safety monitor module, F-2, flight spare	Vibration temperature	3/25/65 3/29-4/3/65	S S
6. Earth sensor, no. 102, flight. Leaked slightly after vibration.	Vibration	3/26/65	U
7. Relay module, F-2, flight spare.	Vibration temperature	3/31/65 4/6-10/65	S S
8. Earth sensor, no. 106, flight.	Vibration	3/31/65	S
9. Optical aspect converter, F-2, flight spare	Vibration	4/6/65	S
10. Command receiver, F-2, flight spare	Vibration	4/12/65	S
11. Two decoders, F-2 O2B, 02D, flight spare	Vibration	4/12/65	S
12. Tracking transmitter, F-2, flight spare	Vibration	4/12/65	S
13. Diplexer, F-2, flight spare	Vibration	4/12/65	S
14. Fuel cell, E-5, flight spare	Vibration	4/22/65	S
15. Pressure relief valve, no. 1, flight	Vibration	4/23/65	S
16. Programmer, F-2, flight spare	Vibration	4/29/65	S
17. Pyrotechnics control card, F-2, flight spare	Vibration	4/29/65	S
18. Experiment selector switch, F-2, flight spare	Vibration	4/29/65	S
19. Catchall card, F-2, flight spare	Vibration	4/29/65	S
20. Telemetry transmitter, flight spare	Vibration	5/18/65	S
21. Ion Mass Spectrometer, flight spare	Temperature	6/7-15/65	S
22. Telemetry encoder, F.U. no. 3, flight. Encoder intermittent before and after the test. Faulty diode was subsequently replaced.	Vibration	6/11/65	U
23. Telemetry encoder, F.U. no. 1, flight	Vibration	7/19/65	S
24. Optical Aspect converter, F.U. no. 2, flight spare	Vibration	9/1/65	S
25. Pressure relief valve, serial no. 2, flight spare	Vibration	9/2/65	S
26. Telemetry encoder, F.U. no. 2, flight	Vibration	9/13/65	S
27. Tape recorder, F.U. no. 1, flight spare	Temperature	9/13-22/65	S
28. Battery Charger, F.U. no. 2, flight spare	Vibration	9/30/65	S
29. Two PG converters, nos. 6 and 7, flight spare	Vibration	12/2/65	S
30. Two telemetry transmitters flight, nos. 9 X 16, 11 X 18	Vibration	1/7/66	S
31. Repaired catch-all card, F.U. no. 1, flight.	Vibration	1/28/66	U
32. Modified turn-on counter, F.U. no. 1, flight.	Vibration	2/7/66	S
33. Repaired tape recorder, F.U. no. 2.	Vibration	2/11/66	S
34. N.P. mass spectrometer less amplifier. Tube no. 16, flight. Filament failed.	Vibration	2/12/66	U

Table II (Continued)
AE-B Flight and Flight-Spare Subassembly Tests

Item	Test	Date	Satisfactory or Unsatisfactory
35. Emission regulator flight, ser. 09	Vibration	2/12/66	S
36. Five NPMS electronics cards flight, sers. 09. 09, 09, 05, 01	Vibration	2/12/66	S
37. Two pressure gage electrometers, flight, sers. A28(U) and A24(S)	Vibration	2/14/66	1S, 1U
38. Repaired tape recorder, flight spare, FU no. 1	Vibration	2/16/66	S
39. Repaired N.P. mass spectrometer, flight, Tube no. 16 filament passed. The spot welds on the magnct bracket failed	Vibration	2/17/66	U
40. Pressure gage electrometer, flight, ser. L-2	Vibration	2/18/66	S
41. NRC pressure gage, flight, ser. 128	Vibration	2/21/66	S
42. NPMS magnet and bracket, flight	Vibration	2/24/66	S
43. Modified turn-on counter, flight, FU no. 2	Vibration	2/25/66	S
44. Repaired tape recorder, flight, no. 2	Vibration	2/25/66	S
45. NPMS magnet, field strength of magnet decreased slightly	Vibration	3/3/66	U
46. Two modified pyrotechnics control cards, flight, nos. 1 and 2	Vibration	3/3/66	S
47. Two modified turn-on counters, flight, nos. 1 and 2	Vibration	3/4/66	S
48. Modified ESS and programmer card, flight, no. 1	Vibration	3/4/66	S
49. ESS and programmer card, flight, no. 2	Vibration	3/9/66	S
50. NPMS magnet	Vibration	3/10/66	S
51. Modified tape recorder, flight, no. 1	Vibration	3/14/66	S
52. Five fuel cells, flight and flight spare, F-1 through F-5	Vibration	3/15/66	S
53. Five fuel cells, flight and flight spares, F-1 through F-5. Although the test was successfully completed, two units later developed small KOH leaks in flight S/C and were replaced.	Acceleration	3/17-18/66	S
54. NPMS emission regulator, flight, no. 8	Vibration	3/21-22/66	S
55. ETP electronics	Vibration	3/30/66	S
56. NPMS magnet, flight spare	Vibration	3/30/66	S
57. Modified tape recorder, flight, no. 2	Vibration	3/31/66	S
58. ETP probe flange, flight, no. 3	Vibration	4/1/66	S
59. Tape recorder, flight, no. 2. ETP electronics, flight spare	Temperature	4/4-8/66	S
60. NRC pressure gage, flight spare. Leaked after test	Vibration	4/11/66	U
61. N.P. mass spectrometer, flight spare. Internal spot weld broken	Vibration	4/14/66	U
62. N.P. mass spectrometer, flight spare	Vibration	4/18/66	S
63. NPMS amplifier, flight spare	Vibration	4/26/66	S
64. GCA pressure gage, flight spare, no. R5-6	Vibration	5/2/66	S

2.3 Flight and flight spare subassemblies

Table II lists the flight and flight spare subassemblies tested, type of test, test date, and test results.

3. TESTING OF VARIOUS SHELLS

Several shells were used throughout the program to test various mechanisms, mountings, structures, solar cells, and thermal properties. The tests were conducted on shell nos. 1. 2, 3, 6, and 8 during the period from June 1964 through March 1966. Although all shell tests were important, perhaps the most significant were vibration tests conducted on shell no. 6 in 1964, 1965, and 1966.

3.1 Shell no. 1 testing

The static unbalance and spin axis moment of inertia were determined August 10, 1964, in preparation for a despin test in the Dynamic Test Chamber (Figure 1). The resulting static unbalance was 18 oz-in., the moment of inertia was 14.787 slug-ft^2, and the weight with the yo-yo despin mechanism and dummy components installed was 458 lbs. The despin test was successfully conducted August 13, when the shell was despun from 60 rpm to a final corrected spin rate of 30.9 rpm in 1.5 seconds. The desired final spin rate was 30 rpm, and the chamber pressure at the time of the test was 1.2×10^{-2} mm Hg.

3.2 Shell no. 2 testing

With the solar cells attached and dummy components installed, shell no. 2 was statically balanced August 19, 1964 in preparation for a vibration test to qualify the design of the solar cells and the method of attaching the cells to the shell. A secondary purpose of the vibration test was to determine if the shell structure would survive the new prototype Delta levels, particularly the low-frequency lateral sinusoidal levels. The static unbalance was 20.5 in.-lbs, and the shell weight 320.5 lbs.

A full vibration test was performed August 20-21, using the new prototype Delta levels except for the second lateral sinusoidal 30-8 cps test at 2.3 g's. After the first lateral sinusoidal 30-8 cps test at 2.3 g's, four spot-weld leaks developed around the base of the shell. It was noted that the shell skin was bent in a few places around the shell base and the test was discontinued. Prior to condúcting the 30-8 cps, 2.3 g's test, the shell successfully completed tests at

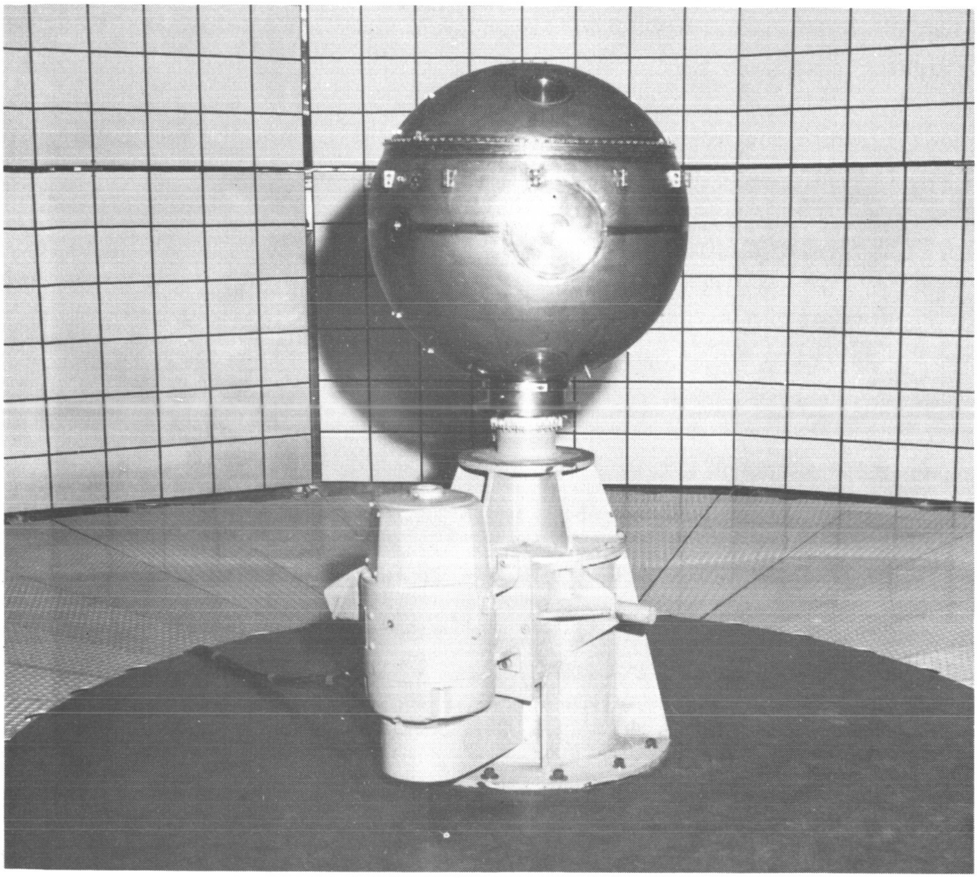

Figure 1—Shell no. 1 in dynamic test chamber after yo-yo despin test.

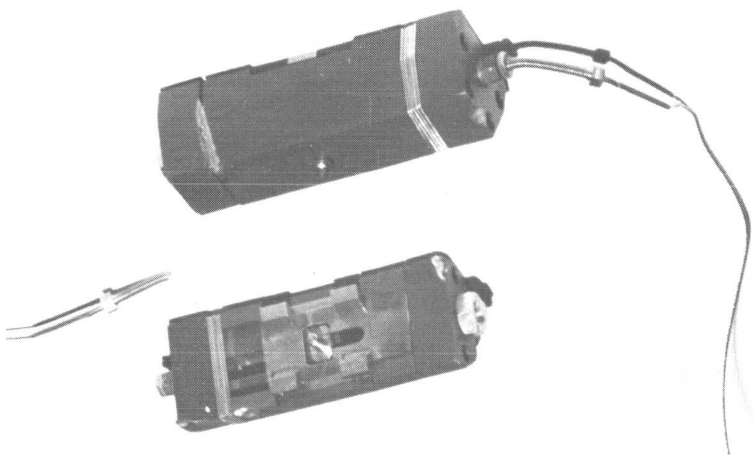

Figure 2—Yo-yo despin weights and cables.

0.9 g's in the 30-8 cps range in both lateral directions. Conclusions derived from the vibration test were:

1. The design of the solar cells and the method of mounting the cells on the shell (Figure 3) were considered to be qualified in vibration.

2. The structure of shell no. 2 survived the new prototype Delta levels except for the low-frequency lateral sinusoidal tests at 2.3 g's; however, it survived the low-frequency lateral sinusoidal tests at 0.9 g's.

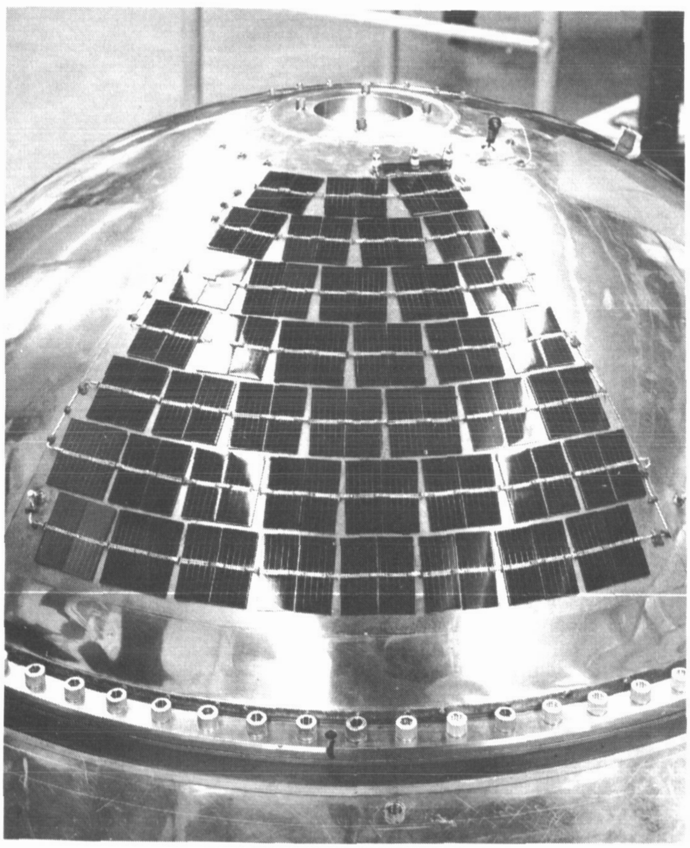

Figure 3–Shell no. 2 showing upper panel of solar cells.

3.3 Shell no. 3 (structural model) testing

A series of vibration tests (Figure 4) were conducted in June and August 1964 to check out the new equatorial mountings of three experiments: the neutral particle mass spectrometer, the ion mass spectrometer, and the pressure gage. In preparation for the test, the static unbalance was determined June 9 to be 167 in.-lbs but after shifting one dummy package, the resulting static unbalance was 66 in.-lbs. The weight of the structural model was 394 lbs. A prototype-level vibration test was successfully completed on the structural model June 12-15, thus qualifying the equatorial mountings of the three experiments. Another test result was an apparent input level buildup at low-frequencies in the lateral directions. Subsequent vibration tests on August 3 and 12 proved that the level buildup was caused by the mounting of the control accelerometer on a cylindrical surface; however, the amplitude of the structural model continued to increase as the frequency decreased to 8 cps in the lateral direction. On August 6 the structural model static unbalance and spin axis moment of inertia were determined; the resulting static unbalance and moment of inertia were 74 in.-lbs and 13.013 slug-ft ^{2}, respectively. The structural model weight was 396 lbs.

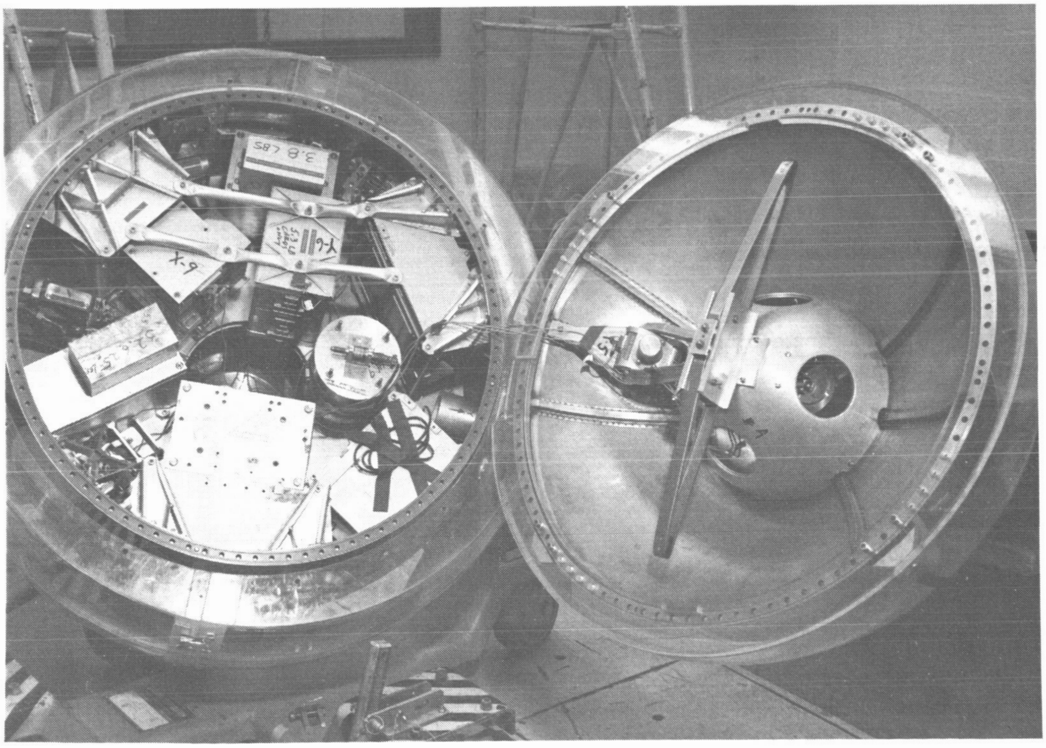

Figure 4–Shell no. 3 (Structural Model) showing some of the accelerometer instrumentation prior to a vibration test.

3.4 Shell no. 6 (S-6 prototype) testing

Vibration test – November 1964 (Figure 5). The S-6 prototype spacecraft was statically balanced October 28, 1964 in preparation for a vibration test. The residual static unbalance was 20.5 in.-lbs, and the final spacecraft weight was 468 lbs. A pre-vibration leak test was performed on the spacecraft November 4, and the resulting total corrected leak rate was 1.8×10^{-6} atm. cc/sec. On November 5 a vibration test was conducted on the spacecraft using a new Douglas Aircraft Company (DAC) furnished Delta attach fitting. The purpose of the test was to determine if the shell structure, loaded to 468 lbs., would survive the lateral, low frequency, sinusoidal portion of the flight acceptance test set forth in the new specification for Delta-launched spacecraft.

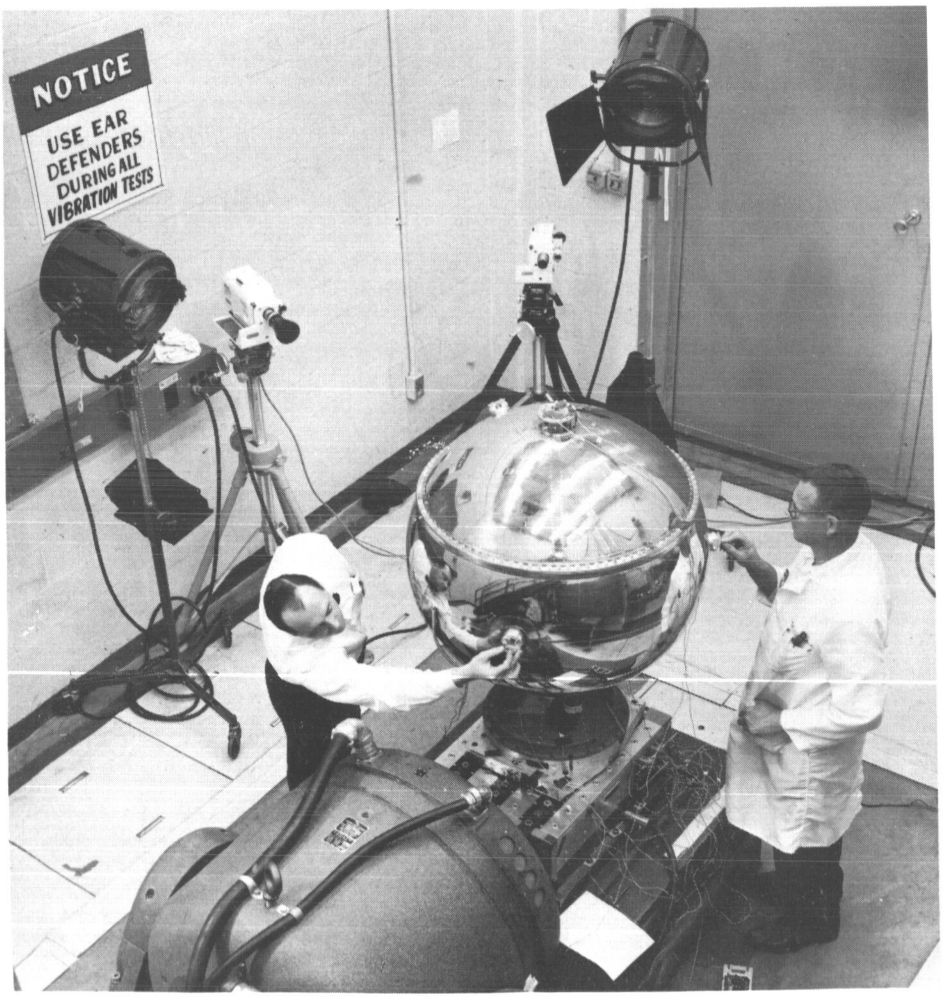

Figure 5–Shell no. 6 being readied for vibration tests in November 1964.

The test consisted of sinusoidal vibration in two perpendicular lateral directions from 30 to 8 cps at 1.5 g's. Two small bulges were detected at the base of the spacecraft after the first lateral test, and four additional small bulges were also detected after the second lateral test. The bulges were small shell areas which were permanently deformed during the test, indicating that the deformed metal was beyond the elastic limit; however, no cracks or ruptures of the metal occurred. A post-vibration leak test was conducted on the spacecraft November 6, and the resulting total corrected leak rate was 1.7×10^{-6} atm. cc/sec., which indicated that the shell structure had remained leak tight. Since no structural failure occurred and the shell remained leak tight, the spacecraft was considered to have successfully completed the vibration test. The fact that small areas of metal were permanently deformed was undesirable, but in this particular case the deformations did not constitute a failure. However, the test results indicated that the structure tested was marginal for the test conditions to which it was subjected.

It should be pointed out that the flight spacecraft shell (no. 8) was somewhat stronger structurally than the prototype spacecraft shell (no. 6). Shell no. 8 was built to an improved design during the S-6 program, and the area where the bulges appeared on shell no. 6 was the area that was improved on shell no. 8. However, the flight acceptance g level increased from 0.6 g to 1.5 g's, and the spacecraft weight increased from 410 lbs. to an estimated 470 lbs. Before the vibration test, a 0.5 g sinusoidal survey from 30 to 8 cps was conducted on the spacecraft in the first lateral direction and it was noted that the Marman clamp torque had relaxed from 56 to 46 in.-lbs. The clamp was re-torqued to 56 in.-lbs between tests, and after the first lateral test at 1.5 g's, the clamp torque was 45 and 52 in.-lbs, but after the second lateral test at 1.5 g's, the clamp torque was 55 and 47 in.-lbs.

Vibration test – May 1965 (Figure 6.) Another vibration test was conducted on shell no. 6 with the primary purpose being to determine if the shell structure, loaded to about 480 lbs, would successfully withstand the specified lateral low-frequency sinusoidal levels. A secondary purpose was to gain added confidence in the structural integrity of the shell design by conducting a full three-axis vibration test at prototype levels, as modified by the Reliability Assurance Council. In preparation for the vibration test, shell no. 6 was statically balanced May 17 to 8.16 in.-lbs, and the spin axis moment of inertia was measured and found to be 15.418 slug-ft^2.

A pre-vibration leak test was conducted May 20, and the resulting total corrected leak rate was 2.2×10^{-7} atm. cc/sec. On May 24, 1965 shell no. 6, loaded to 480 pounds, was subjected to a vibration test in a lateral direction. The first step was a sinusoidal sweep from 500-5 cps at 0.5 g. A decision was made to remove the key in the clamp that was used to secure the spacecraft to

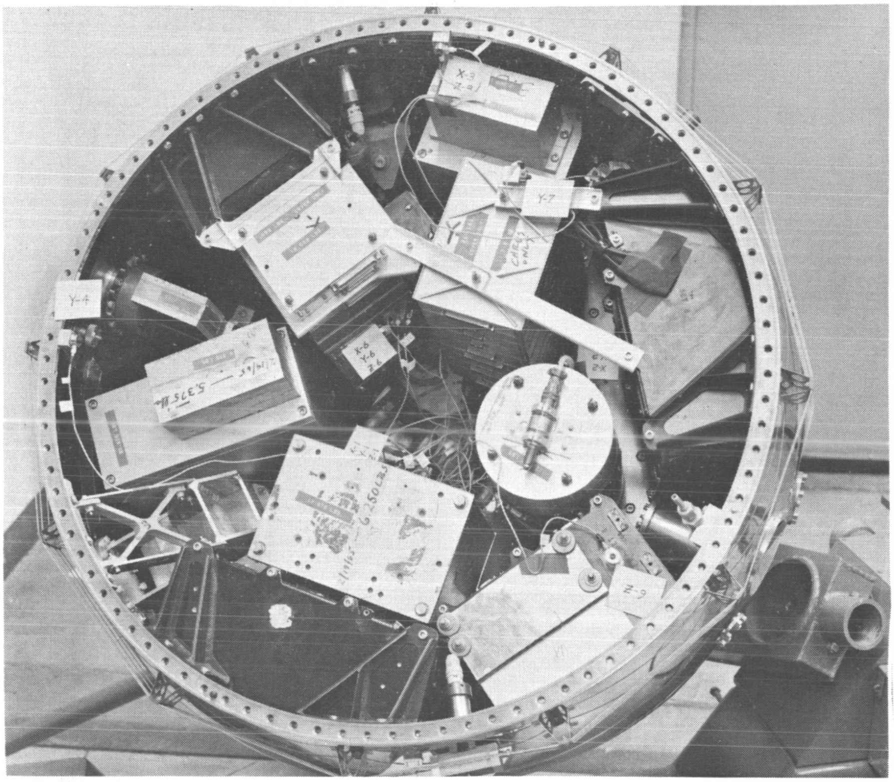

Figure 6—Shell no. 6 showing some of the accelerometer instrumentation for a vibration test in May 1965.

the attach fitting. During the test the spacecraft rotated about 5° in a clockwise direction as viewed from the top and at this point it was decided to install the key from the lightweight clamp in the heavyweight clamp with aluminum rivets. The second step was a sinusoidal sweep from 30-8 cps at 1.0 g. During the test the aluminum rivets were sheared and the shell skin was permanently deformed in two places near the base of the spacecraft. A post-test inspection revealed galled mating surfaces, improper mating of the spacecraft to the attach fitting, and indications of a large torque in the clockwise direction.

A post-vibration leak test was conducted May 26, and the resulting total corrected leak rate was 2.5×10^{-7} atm. cc/sec., indicating that the shell remained leak tight. The results of a post-test dimensional analysis of the shell base dimensions indicated that the base flatness was out-of-tolerance about 0.006 inch, and that the inside and outside base diameters were somewhat too large. The center of gravity was measured May 26 and was 17.07 inches above the shell base, and on May 27, the static and dynamic unbalance were found to be 73 oz-in. and 19,067 oz-in.^{2}, respectively.

Torque tests were performed June 2-3. The tests on June 2 essentially confirmed a lateral resonance of about 11 cps, and the results of the tests on June 3 indicated that a torsional resonance occurred at about 37 cps. There was general agreement that the torsional resonance did not present a significant problem and that the lateral resonance was of much greater significance.

Vibration tests – June 1965 (Figure 7.) Two 0.5 g, 30-8 cps, Y^1 - Y^1 direction, sinusoidal vibration tests were conducted on June 4. The first test was conducted with no shimming, and the second test was conducted after shimming the spacecraft base. Although a better fit was achieved by shimming, which in turn probably reduced the gapping, "banging" was not significantly reduced according to oscillograph data. The Q at the spacecraft center of gravity (C.G.) actually increased from 4.5 to 6.5 as a result of shimming. The shell rotated slightly in the clockwise direction, as viewed from the top, until it was stopped by the seating of the clamp key. The torque measured during the test was about 300 ft-lbs, and the lateral resonance occurred at 15 cps.

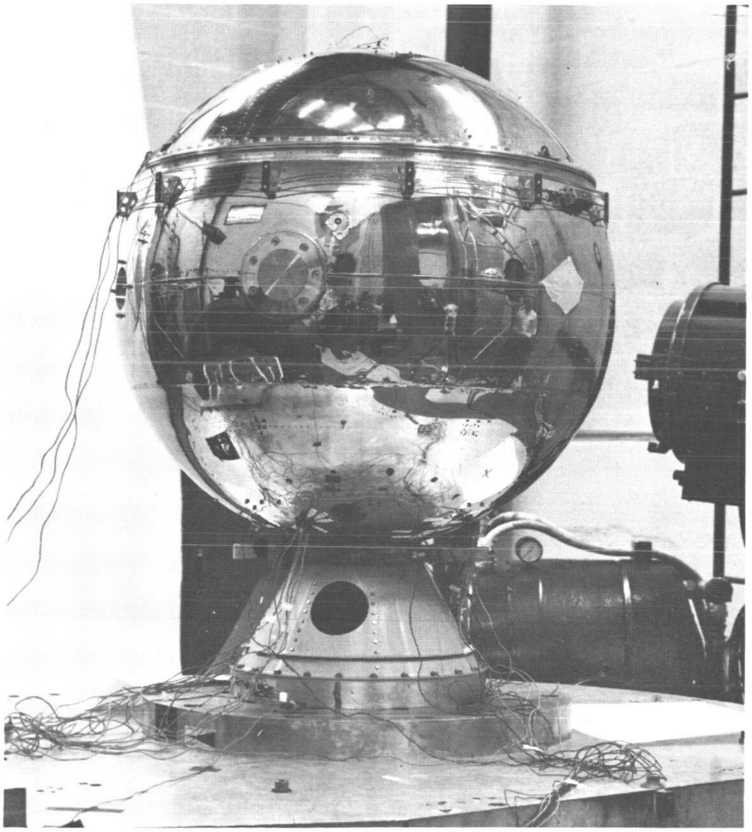

Figure 7–Shell no. 6 undergoing vibration tests in June 1965.

On June 5 the shell was aligned in preparation for dynamic balancing (statically balanced prior to vibration); dynamic balancing began June 7. Inspection of the shell interior on June 8 while on the balancing machine revealed that two gussets at the shell base were slightly bent. This was a result of the 1.0 g lateral vibration test conducted May 24 and indicated that the test was more severe than originally estimated. Balancing continued until June 9, when a decision was made to remachine the shell base to improve the surface flatness. The shell was removed, disassembled, and taken to building 5 for remachining. Balancing was resumed June 19 and was completed June 21. The residual static and dynamic unbalance were 46 oz-in. and 381 oz-in.^{2}, respectively, and the total weight after balancing was 481 lbs. The C.G. of the shell was 17.05 inches above the interface.

A pre-vibration leak test was conducted June 22, and the total corrected leak rate was 4.3×10^{-7} atm. cc/sec.

Shell no. 6, loaded to 481 pounds, successfully completed a full three-axis vibration test June 23-24, 1965, at modified prototype Delta levels (included 0.75 g's in the lateral 30-8 cps range). A mid-vibration leak test was conducted June 23, and the total corrected leak rate was 2.8×10^{-6} atm. cc/sec. A post-vibration leak test was conducted June 25, and the resulting total corrected leak rate was 3.1×10^{-6} atm. cc/sec. No permanent deformation of the shell structure was noted as a result of the test. Post-test inspection inside the shell revealed that two packages had pulled loose during the test; a third package was slightly loosened. All three packages were overweight and had no supporting brackets.

Yo-Yo Despin tests. On June 28 measurements were made to determine the moment of inertia about the spin axis and the resulting moment of inertia was 15.487 slug-ft^2.

Yo-Yo despin tests were also conducted on June 28, 1965 at the Agricultural Research Center (ARC) Airport; two tests were conducted, and both were successful.

Practice test set-up and handling exercises. A practice set-up and handling exercise was conducted October 20-21, 1965 in the 7' × 8' solar vacuum chamber using shell no. 6 loaded to 480 lbs. The spacecraft was spun at 30 rpm at the aspect angles (0°, 90°, and 135°) planned for the solar vacuum test on the flight spacecraft. Spacecraft telemetry was commanded on, satisfactory signals were received and no difficulties were encountered during the exercise. A satisfactory practice set-up and handling exercise was also conducted October 26 at the Magnetic Fields Component Test Facility using shell no. 6. The spacecraft telemetry was commanded on, and satisfactory signals were received. On December 3 shell no. 6 was transported to the Naval Ordnance Laboratory for a practice setup and handling exercise. The exercise was conducted December 6 in building no. 203 in preparation for magnetic tests on the flight spacecraft.

Preliminary Solar Simulation Tests (Figure 8.) A preliminary solar simulation test in the 7' × 8' solar simulation chamber began on January 12, 1966 and was terminated later that day because the gimbal spin motor would not rotate the spacecraft at an aspect angle of 0°. The test was resumed January 13, but was stopped January 14 because the spin motor would not rotate the spacecraft at aspect angles of 135°, 0°, and some intermediate angles. The spin motor was repaired January 15 and 16, and the test was resumed January 17, but on January 18 the spin motor again failed at an aspect angle of 0° after working for about 30 minutes. On January 19 shell no. 6 was removed from the gimbal and the static unbalance was measured and found to be 4.83 ft-lbs. The torque generated by the gimbal spin motor in the 7' × 8' chamber was 3 to 4 ft-lbs and was therefore not sufficient to rotate the shell at some aspects. The shell was statically balanced February 9 to an unbalance that varied from .55 to 1.975 ft-lbs depending on the orientation of the shell on the Miller Facility. Based on a vector analysis, a weight was subsequently added to the shell which reduced the unbalance to less than 1 ft-lb.

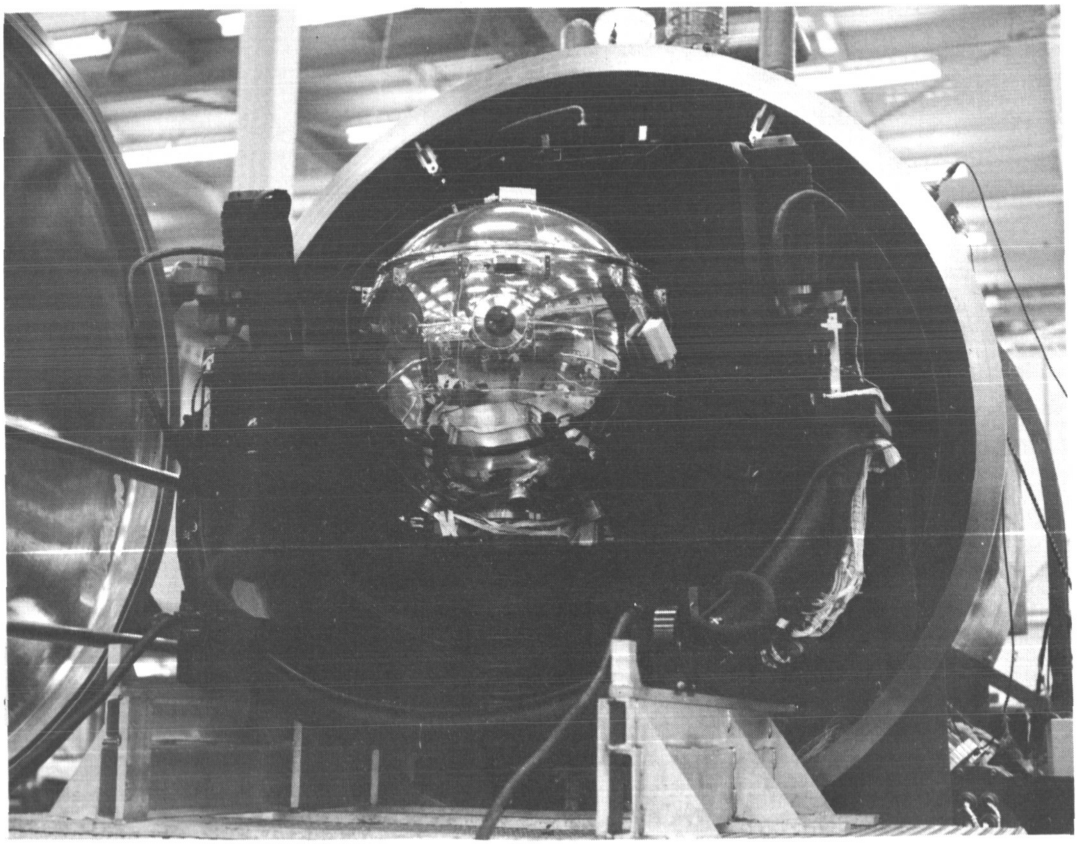

Figure 8–Shell no. 6 prior to solar simulation test.

On February 11 shell no. 6 was remounted on the 7 × 8 gimbal for the demonstration test, and at ambient conditions the gimbal spin motor apparently operated normally at various aspects. An attempt was made February 12 and 13 to conduct the demonstration test, but the spin motor stopped rotating after about 45 minutes in the 90° aspect. Instrumentation indicated that the spin motor armature temperature reached 110°C. On February 14 the spin motor was disassembled, and a thermally conducting epoxy was applied to the shaft-armature interface to provide a conducting path from the armature. A second attempt was made February 15-18 to conduct the demonstration test. After about 3-1/2 hours of rotation in the 90° aspect were completed (armature temperature reached 74°C), the test was halted because a leak developed in a chamber connector. After replacement of the connector the test was resumed, and 4 hours of rotation in the 90° aspect were satisfactorily completed, (armature temperature reached 64°C). In attempting to run at other aspects, the spin motor stopped rotating (armature temperature peaked at 99°C), and difficulty was also experienced with the tilt motor which was used to change the aspect angle. The test was then discontinued to permit repairs on the tilt motor and additional repairs on the spin motor. A third attempt was made February 25-27 to carry out the demonstration test. The gimbal spin motor stopped rotating after 140, 35, and 34 minutes out of three starts in the 90° aspect. A successful demonstration test was conducted in the 7' × 8' solar simulation chamber on March 5-6 after installation of an auxiliary drive motor to provide spacecraft rotation. The new motor operated 32 hours at test conditions in the 90°, 0°, and 135° aspects, thus demonstrating full facility capability.

Vibration test – March 1966. A leak test was conducted on March 2, 1966, and the total corrected leak rate was 2×10^{-6} std. cc/sec. On March 8 shell no. 6 successfully completed thrust-direction vibration tests at 4 g's and 6 g's in the 16-18 cps range. The test was a requirement based on new Delta vehicle vibration data.

3.5 Shell no. 8 (flight) testing

Shell no. 8 was leak tested September 24, 1964 and the resulting total corrected leak rate was 4.3×10^{-6} atm. cc/sec. On September 25, the shell was probed using a leak detector, and three small leaks totaling 3.6×10^{-6} atm. cc/sec were detected at three different ports in the shell. A thermal-vacuum test was conducted on December 22-24, 1964 with solar cells to provide data for determining the emissivity of the shell. Data analysis was performed by personnel of the Thermal Systems Branch.

4. FLIGHT SPACECRAFT TESTING

4.1 Flight spacecraft test specification

The test specification for the AE-B flight spacecraft is contained in a document entitled "Environmental Test Specification for the Atmosphere Explorer-B Spacecraft," report number S-320-AT-1A dated December 10, 1965 superseding S-320-AT-1 dated February 18, 1965.

In general, spacecraft testing was conducted in accordance with the test specification. The solar simulation test duration totaled about five days and was limited to aspect angles of 0° and 90°. Extensive temperature tests were conducted on the spacecraft, mainly preceding solar simulation testing. An additional vibration test was conducted on the flight spacecraft at the time of the final vibration test. The additional test was a new requirement based on Delta vehicle data and consisted of sinusoidal vibration at 4 g's from 16-18 cps in the thrust direction.

4.2 Preliminary flight spacecraft testing

Mock-up spacecraft temperature test

A preliminary temperature test began on the mock-up spacecraft February 19, 1965 (Figure 9) and was terminated temporarily February 21. During this period several spacecraft checkouts were conducted between -10°C and 45°C, which indicated that the equatorial neutral-particle mass spectrometer was noisy at -10°C. The tape recorder exhibited some noise the first time at -10°C but not the second time; electron temperature probe no. 2 evidenced some 60 cps noise at -10°C, and at 45°C the turn-on counter experienced a failure in one stage. Otherwise, the spacecraft electronics functioned satisfactorily. An ambient temperature checkout on February 23 was satisfactory except for the turn-on counter. Prior to beginning the temperature test some difficulty was experienced with the magnetic attitude and spin rate control electronics, and it was removed from the system for modification.

The temperature test on the mock-up spacecraft resumed March 3 and was concluded March 6. During this period, spacecraft checkouts were conducted at -10°C and 45°C. At -10°C a problem was noted with the tape recorder/telemetry interface circuitry which was solved by incorporating two diodes in series into the circuitry. Subsequent spacecraft checkouts at -10°C and 45°C were found to be satisfactory. The magnetic attitude and spin rate control electronics were in the system during this period and functioned satisfactorily but the ion mass spectrometer was not. It was checked out satisfactorily during the first temperature cycle February 19-21 and was returned to the experimenters for calibration.

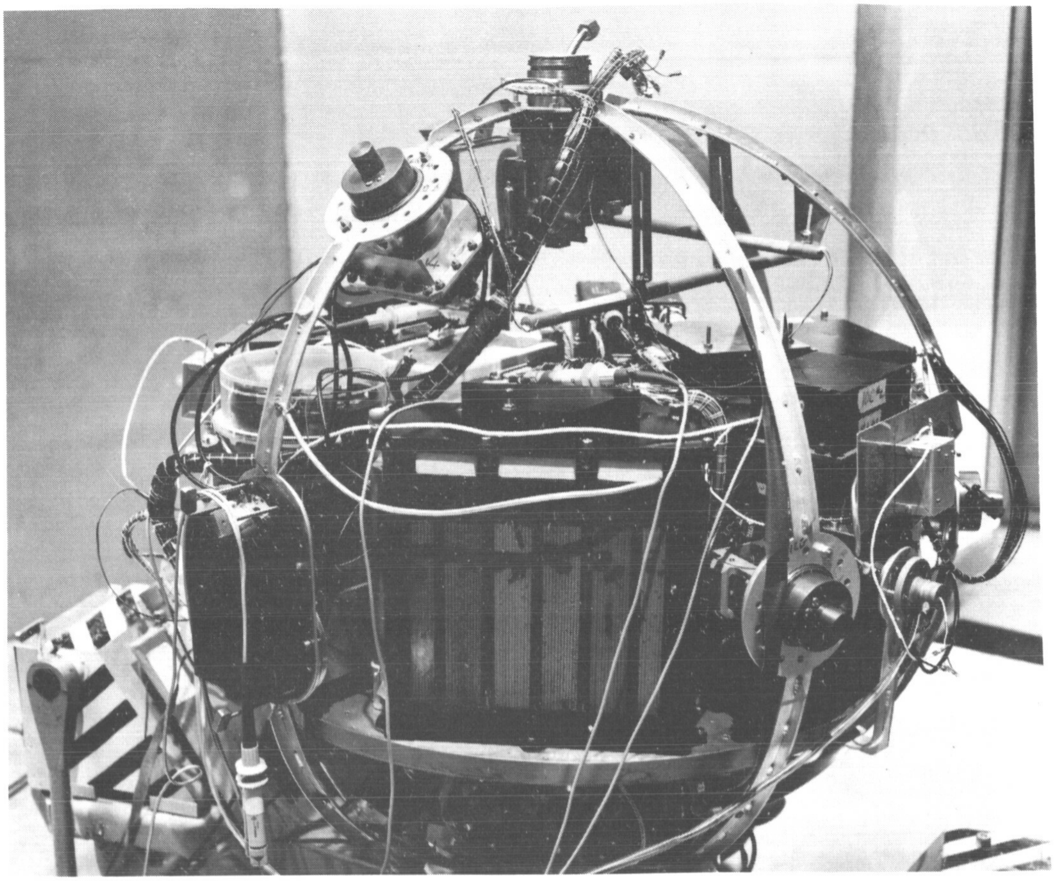

Figure 9—Mock-up spacecraft undergoing temperature test in 12′ × 12′ × 20′ temperature chamber.

Magnetic tests

A magnetic survey was conducted March 8, 1965 on the mock-up spacecraft to determine the field strength magnitudes at various spacecraft locations.

A preliminary magnetic test was performed April 29 and 30, 1965 on the flight spacecraft at the Naval Ordnance Laboratory to determine the magnitude of the permanent magnet required to compensate the magnetic moment of the spacecraft. Also, on May 24-25, 1965 a magnetic test was performed to determine the initial magnetic moments of the spacecraft prior to beginning the acceptance test program. The flight spacecraft was suspended by a long cable June 1, 1965 in building no. 10 to demonstrate the operation of the magnetic spin rate control subsystem, and was commanded to spin in both directions several times, but the resulting rotation was too small to detect. Therefore, it was considered that the test was inconclusive.

Moments of inertia

Measurements were made May 12, 1965 on the flight spacecraft to determine the preliminary moments of inertia. The resulting moments of inertia about the Z, X, and Y axes were 14.89, 13.13, and 12.85 slug-ft^2, respectively, and the spacecraft weight was 473.4 lbs.

Balancing

Preliminary balancing of the flight spacecraft was performed from June 10-14, 1965. The residual static and dynamic unbalance were 48 oz-in. and 1171 oz-in.^{2}, respectively. The balancing weight added was 15.3 lbs, and the total spacecraft weight after balancing was 484.2 lbs. The center of gravity of the spacecraft was 17.1 inches above the interface.

Leak tests

A series of leak tests was successfully conducted on the flight spacecraft from August 2-6, 1965, and the initial total leak rate of the spacecraft was 8×10^{-7} atm. cc/sec. The pressure relief valve was commanded open, and the resulting pressure loss rate was 3.6 pounds per square inch (psi) in 24 hours using either helium or nitrogen in the spacecraft. The pressure check valve closed at approximately 18 pounds per square inch absolute (psia) and opened at approximately 23 psia. During the test the pressure relief valve responded properly to all commands, and the pressure check valve functioned normally. The final total leak rate of the spacecraft was 2.45×10^{-6} atm. cc/sec.

4.3 Flight spacecraft acceptance testing

Initial magnetic tests. Flight spacecraft acceptance testing began December 6, 1965 with the initial magnetic test at the Naval Ordnance Laboratory and was exposed to a deperming field of 50 gauss ac in the X, Y, and Z axes. The magnetic tests were successfully completed December 9, and the spacecraft was returned to GSFC. On December 13 one leaky HR-40 battery was detected in the spacecraft, and subsequently the leaky battery and five others in the same pack were replaced.

Initial balancing. The spacecraft was initially balanced in the launch configuration during the period December 16-20, 1965. The spacecraft unbalance was then measured in the semi-orbital configuration (with the break-off mechanisms off and the caps on), and in the simulated orbital configuration (with the break-off mechanisms off and with compensating weights on to counteract the effect of the caps). The residual static and dynamic unbalance for the three spacecraft configurations were:

Spacecraft Configuration	Spacecraft unbalance	
	Static (oz-in.)	Dynamic (oz-in.^{2})
Launch	61	223
Semi-orbital	225	1310
Simulated orbital	366	1698

The total spacecraft weight was 489 pounds of which 15.6 pounds was balancing weight, and the C.G. of the spacecraft was 17.11 inches above the interface.

Initial moments of inertia. Initial spacecraft moments of inertia measurements were made December 21, 1965. The resulting moments of inertia were:

Axis	Moment-of-inertia (slug-ft^2)
Z-Z	15.5
Y-Y	13.0
X-X	13.4
Y-Y plus 27.5°	13.6 (maximum lateral M.I.)
Y-Y plus 117.5°	12.8 (minimum lateral M.I.)

Leak test. A pre-vibration leak test was conducted on the spacecraft December 28, 1965, and the corrected leak rate was 9.4×10^{-8} atm. cc/sec.

Vibration test. On December 29-30, 1965, the flight acceptance vibration test (Figure 10) was conducted on the spacecraft. A flight-type attach fitting, clamp, and calibrated spacers were used in mounting the spacecraft.

As a result of the test, two spacecraft problems developed; otherwise, the spacecraft successfully completed the test. After the first lateral axis test, the equatorial neutral particle mass spectrometer did not function properly. After completion of the test, the equatorial mass spectrometer data indicated further degradation. The second problem involved the stepper switch in the safety monitor subsystem which could not be commanded via telemetry after completion of

Figure 10–Flight spacecraft undergoing vibration test.

the test. The test results indicated that in both lateral directions the spacecraft resonance occurred at 14 cps.

During the thrust axis test, some mild "noise" was detected in the 15 to 10 cps range near the bottom of the spacecraft. This might have been caused by minute "gapping and banging" of the spacecraft base on the attach fitting or by parts internal to the spacecraft.

A detailed vibration test report is contained in reference 21.

Leak test. A post-vibration leak test was conducted on the spacecraft January 4, 1966. The resulting total corrected leak rate was 2.1×10^{-7} atm. cc/sec, thus indicating that the shell remained leak tight.

Temperature test. Pre-test checkouts of the spacecraft resulted in a minor modification to both flight telemetry transmitters to reduce interference with the command receivers. Both telemetry transmitters subsequently passed flight-level subassembly vibration tests on January 7, 1966. Temperature tests were also successfully completed by the Space Electronics Branch.

Spacecraft checkouts on January 12 prior to beginning the temperature test revealed two spacecraft problems: One bad thermistor, and command receiver No. 1 would not respond to command No. 26.

The temperature test began January 12 and was completed January 20. Spacecraft checkouts were conducted at -10°C and 45°C, and the following spacecraft problems were noted:

1. The turn-on counter jumped 7 counts, either at -10°C or while changing from 45°C to -10°C. Also, at 45°C the counter consistently counted by twos.
2. The tape recorder did not function properly at -10°C and 45°C. The bit error was noted to be excessive. The flight spare tape recorder exhibited similar symptoms at -10°C.
3. The magnetic attitude control subsystem did not function properly at -10°C. The subsystem turned on in the manual mode but cut off after a few seconds of operation. It would not function in the automatic mode but after replacement of the catchall card, the subsystem functioned properly.
4. At -10°C the neutral particle mass spectrometer data exhibited excessive noise. This was attributed to a pressure build-up in the equatorial neutral particle mass spectrometer tube. Apparently, thermal cycling opened

up the seal and increased the leak rate beyond the capacity of the vac-ion pump. On January 16, the high-voltage connector on the equatorial vac-ion pump was loose, and arcing was noted.

5. At 45°C the potting in the experiment selector and the calibration card was noted to be soft in spots.

6. On January 18 a leak developed in the upper neutral particle mass spectrometer at about 3°C. Electrical checkouts on both NPMS's were subsequently discontinued.

7. The tracking transmitter turned on spuriously for 5-second intervals.

8. A wiring harness change involving both encoders was found to be necessary.

9. An extra pulse was noted from one encoder clock to the tape recorder.

10. A resistance increase was noted in the encoder thermistors.

Leak test. A pre-solar simulation leak test was conducted January 29, 1966 on the flight spacecraft, and the resulting total corrected leak rate was 9.7×10^{-7} std. cc/sec.

Static balancing. The flight spacecraft was statically balanced February 1, 1966 to minimize the effect of unbalance on the gimbal spin motor in the 7' by 8' chamber. For the orbital configuration the initial spacecraft unbalance was 0.948 ft-lb; and after adding 6.2 oz. of balance weight, the residual unbalance was 0.34 ft-lb. For the launch configuration, the residual spacecraft unbalance was 0.34 ft-lb. after adding 6.5 oz. of balance weight.

Solar simulation test -0° aspect. A solar simulation test on the flight spacecraft was conducted February 2-4 and was limited to testing in the 0° aspect with no spacecraft rotation. At or near stabilization, the observed skin maximum and minimum temperatures were 55°C and -31°C, and the battery temperatures ranged from about -12°C to 12°C.

The following spacecraft problems were noted during the test:

1. The filament in the equatorial neutral particle mass spectrometer was apparently damaged which later proved to be a harness wiring problem.

2. Two wiring errors in external spacecraft plugs (not flight items) precluded the firing of pyrotechnics, and were repaired February 8.

3. The tape recorder (flight spare) data continued to be noisy.

4. The vac-ion pump high voltage converter (not a flight item) for the upper neutral particle mass spectrometer failed (transistor).

After the spacecraft was removed from the solar simulation chamber, a thin coating was observed on the metal surfaces of the shell. A chemical analysis was conducted to identify the coating and its source. The results of the analysis indicated that the thin coating was sulfinated lard oil which emanated from the yo-yo despin cables. Apparently, sulfinated lard oil was used in the manufacture (twisting) of the cables. The yo-yo cables were removed from the spacecraft and cleaned.

Yo-Yo despin test. A yo-yo despin test was conducted February 18, 1966 on the flight spacecraft at the ARC Airport. Although the command to fire the yo-yo squibs was received by the spacecraft, the yo-yo squibs failed to fire as planned. Despin was achieved via the programmer after 170 seconds.

Temperature retest. The flight spacecraft began a temperature retest February 24, 1966. Spacecraft checkouts were conducted February 25 and 26 at -10°C and February 27 at 45°C. The following problems were noted:

1. Tape recorder playback data were bad at times.
2. The turn-on counter missed counts.
3. Pressure gages did not calibrate via 170-second timer, which was attributed to the experiment selector and calibration card.

The temperature test was temporarily halted February 28, pending resolution of the spacecraft problems. On March 1 the temperature test was resumed with the following modified electronics cards (two were partially depotted) in the spacecraft: pyrotechnics control card, turn-on counter, and ESS and programmer card. Spacecraft checkouts were made March 2 at -10°C, the results indicated that the modifications were satisfactory and that the tape recorder problem persisted. The test was temporarily halted March 3, and the three electronics cards and tape recorder were removed from the spacecraft. The remaining two cards were then potted, and all three cards successfully completed flight-level vibration tests on March 3-4. On March 4 the cards were reinstalled and a modified tape recorder was installed on March 5. After several satisfactory ambient checkouts, the temperature test was resumed and on March 6, more spacecraft checkouts were made at -10°C; but the results indicated that the tape recorder modification was not satisfactory. The test was then terminated, and on March 7 the spacecraft was removed from the temperature chamber to begin preparations for the solar simulation test.

Leak test. A pre-solar simulation leak test was conducted March 8 on the flight spacecraft, and the total corrected leak rate was 9.1×10^{-7} std. cc/sec.

Solar simulation test. The flight spacecraft solar simulation test (Figure 11) specification was modified so that the test consisted of the following steps:

Aspect	Percent lighting	Approximate time,* hours	S/C spin rate, rpm
90°	62% (cycling on 62 min, off 38 min.)	48	30
90°	100%	24	30
0°	100%	24	30

*Or until spacecraft temperatures stabilized or temperature cycling repetitive.

The solar simulation test was conducted during the period March 10-14, 1966 and was successfully completed except as noted below. The tape recorder in the spacecraft for the test was known to have a problem prior to the test. Parallel effort was directed toward resolving the problem while the solar simulation test was being conducted:

1. The tape recorder did not function properly.
2. The equatorial neutral particle mass spectrometer was disabled throughout the test and the mass spectrometer was replaced when the spacecraft was disassembled for installation of flight batteries and fuel cells.
3. The NRC pressure gage did not function properly.
4. Difficulty was experienced early in the test in (a) commanding the safety monitor subsystem from building no. 14, and (b) executing command nos. 26 and 28 (magnetic attitude control system). Difficulty was occasionally experienced with command no. 26 and other commands later in the test. Some of the real time data and playback data exhibited noise which was attributed to the chamber auxiliary drive motor. Some of the difficulty in commanding was also attributed to the auxiliary drive motor.

The chamber auxiliary drive motor functioned well during most of the test, but near the end the spin rate fluctuated down to zero. At this point the test was essentially completed.

A more detailed solar simulation test report is contained in reference 25.

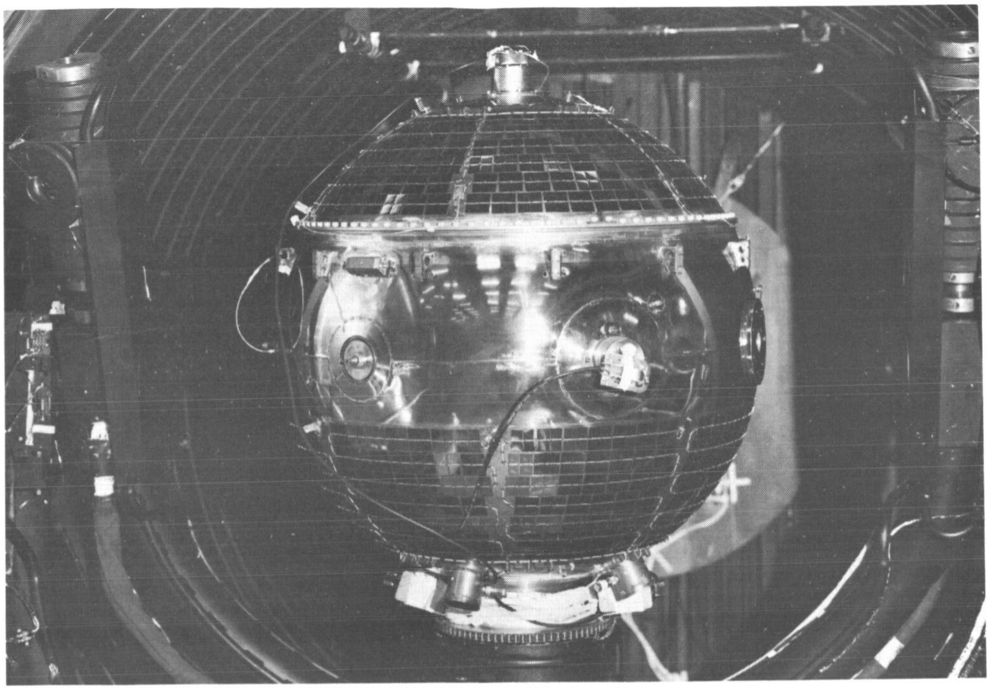

Figure 11–Flight spacecraft being readied for solar simulation test.

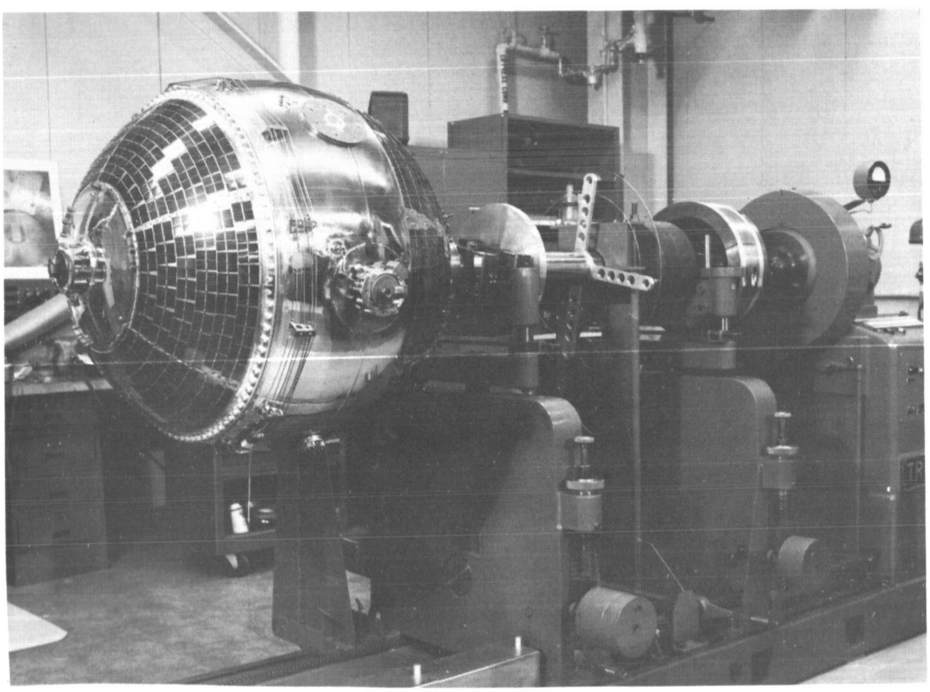

Figure 12–Flight spacecraft in final balance operation.

Temperature retest. The flight spacecraft successfully completed a temperature retest March 15-16, 1966 with a modified tape recorder installed. Several spacecraft checkouts were made at -10°C and 45°C, and all indicated that the tape recorder operated satisfactorily.

Yo-Yo despin retest. The flight spacecraft successfully completed a yo-yo despin retest March 17, 1966 at the ARC Airport.

Disassembly and reassembly. Disassembly and reassembly of the flight spacecraft were performed during the period March 17-27, 1966. Spacecraft changes effected during disassembly and reassembly included: installation of new flight batteries and fuel cells, and replacement of the equatorial neutral particle mass spectrometer and optical aspect earth sensor.

Leak test. A leak test was conducted March 27, 1966 on the spacecraft following reassembly, and the total leak rate was 2.4×10^{-7} atm cc/sec.

Final balancing. Final balancing of the flight spacecraft (Figure 12) was accomplished during the period March 28-30, 1966. The spacecraft was balanced in the orbital configuration to an unbalance of 9 oz-in. static and 205 oz-in.^{2} dynamic. The spacecraft unbalance was then measured for the launch configuration and was found to be 327 oz-in. static and 980 oz-in.^{2} dynamic.

On March 30, while in the launch configuration, the spacecraft was weighed and the resulting weight was 485.4 lbs. which included 11.39 lbs. of balance weight. The spacecraft C.G. for the launch configuration was 17.10 inches above the separation plane.

Final moments of inertia. The spacecraft moments of inertia were determined March 30-31 and were as follows:

Axis	M.I., slug-ft^2
Thrust axis (Z-Z)	15.3
Lateral axis (27.5°)	13.6 (Maximum)
Lateral axis (117.5°)	13.0 (Minimum)

Final vibration test. The final spacecraft vibration test was conducted April 2, 1966 which consisted of sinusoidal vibration at 4 g's (0-peak) from 16-18 cps and random vibration at 7.7 g-rms for 0.5 minute, all in the thrust direction. The spacecraft successfully completed the test except as noted on the following page:

1. No. 1 telemetry transmitter connector was noted to be disconnected after the test.
2. Four connector retaining clips and four screws were found in the bottom of the spacecraft after the test.
3. The thermistor channel in encoder no. 2 appeared to have a faulty gate which indicated a high resistance and consequently a lower voltage reading.

Leak test. A spacecraft leak test was conducted April 2, and the total corrected leak rate was 1.9×10^{-6} std. cc/sec. The pressurization port in the spacecraft was cup tested and was found to have a leak rate which essentially accounted for the total spacecraft leak rate. During the leak test, a full set of spacecraft ordnance was successfully fired in the chamber.

Final Magnetic Tests. Final spacecraft magnetic tests at the Naval Ordnance Laboratory were successfully completed April 4-6, 1966. During the tests, a defective Y-Y axis electromagnet was detected and replaced. The tests also resulted in the installation of two trim magnets on the spacecraft exterior to provide a small correction in the spin axis dipole moment.

The flight spacecraft successfully completed magnetic torque tests April 7-8 in the Magnetic Field Component Test Facility at GSFC. Essentially the test verified proper operation of the magnetic spin rate control subsystem. A detailed test report is contained in reference 27.

The successful completion of the final magnetic tests marked the end of the flight spacecraft acceptance test program.

Flight Spacecraft Test Performance Summary. A summary of the flight spacecraft acceptance test program is presented in the following chart.

AE-B

FLIGHT SPACECRAFT

TEST PERFORMANCE SUMMARY

December 6, 1965 to April 8, 1966

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		TEST CONDITION	Magnetic Test (NOL)	Not Under Test	Initial Weight CG and Balance	Initial Moments of Inertia	Leak Test	Vibration Test	Leak Test	Not Under Test	Pre-Test Checkout	Temperature Test -10°C and 45°C	Not Under Test	Leak Test	Static Balance	Solar Simulation Test 0° Aspect	Yo-Yo Despin Test	Not Under Test	Temperature Test -10°C and 45°C	Not Under Test	Temperature Test -10°C	Temperature Test -10°C	Leak Test
		S/C Configuration OPERATING MODE	Orbital, Operating	Top Off, Non-Operating	Launch, Orbital, Non-Operating	Launch, Non-Operating	Launch, Non-Operating	Launch, Beacon On	Launch, Non-Operating	Top Off, Operating	Top Off, Operating	Top Off, Operating	Top Off, Operating	Launch, Non-Operating	Orbital, Launch Non-Operating	Launch, Operating	Launch, Operating	Top Off, Non-Operating	Top Off, Operating	Top Off, Operating	Top Off, Operating	Top Off, Operating	Launch Non-Operating
		DATE	12/6/65 12/9/65	12/13/65 12/15/65	12/16/65 12/20/65	12/21/65	12/28/65	12/29/65 12/30/65	1/4/66	1/4/66 1/11/66	1/12/66	1/13/66 1/20/66	1/21/66 1/28/66	1/29/66	2/1/66	2/2/66 2/4/66	2/18/66	2/23/66	2/24/66 2/28/66	2/28/66 3/1/66	3/1/66 3/2/66	3/5/66 3/7/66	3/8/66
EXPERIMENTS	Electron Temperature Probes (2)	A																					
	N. P. Mass Spectrometers (2)	B						◫		■ C		◪	R			◪ ◫							
	Pressure Gages (3)	C																C					
	Ion Mass Spectrometer (1)	D																					
SPACECRAFT SUBSYSTEM	Battery Packs	E		■ NC																			
	Command Receiver	F									◪												
	Tracking Transmitter	G										◫											
	PCM Telemetry	H								M		◪	M										
	Antenna	I																					
	Solar Cell - Battery Charge	J																					
	Program and Control	K										◪ C◫	RM			◪ I	◪		◪	M			
	Tape Recorder	L										◪	R			◪			◪		◪	M◪	
	Optical Aspect	M																					
	Thermistor-Pressure Monitor	N								C	■		C										
	Safety Monitor	O						◫															
	Leak Valve	P																					
	Magnetic Attitude Control	Q										◪	R										
	Nutation Damper	R																					
	H_2 Recombination Cells	S																					
		T																					

CODE

E - Facility Induced Problem
■ - Failure
◪ - Questionable Operation
⊟ - Marginal Operation

⊠ - Procedural Failure
◫ - Special Problem
R - Subsystem Repaired
C - Subsystem Changed

M - Subsystem Modified
D - Subsystem Redesigned
N - Subsystem Not Under Test
S - Special Operating Condition for Test

320-87(3/65)

AE-B

FLIGHT SPACECRAFT

TEST PERFORMANCE SUMMARY

December 6, 1965 to April 8, 1966

(Continued)

		TEST CONDITION	Solar Simulation Test	Temperature Test $-10^{\circ}C$ and $45^{\circ}C$	Yo-Yo Despin Test	Not Under Test	Leak Test	Final Weight, C.G., and Balance	Final Moments of Inertia	Pre-Vibration Checkout	Final Vibration Test	Leak Test and Ordnance Firing	Final Magnetic Tests
		S/C Configuration OPERATING MODE	Orbital, Operating	Top Off, Operating	Launch, Operating	Disassembled and Reassembled	Launch, Non-Operating	Orbital and Launch Non-Operating	Launch, Non-Operating	Top Off, Operating	Launch, Beacon On	Launch, Operating	Orbital Operating
		DATE	3/9/66 3/14/66	3/14/66 3/16/66	3/17/66	3/17/66 3/27/66	3/27/66 3/28/66	3/28/66 3/30/66	3/30/66 3/31/66	3/31/66 4/1/66	4/2/66	4/2/66	4/4/66 4/8/66
			22	23	24	25	26	27	28	29	30	31	32
EXPERIMENTS	Electron Temperature Probes (2)	A								◩ C			
	N. P. Mass Spectrometers (2)	B	N			CR							
	Pressure Gages (3)	C	◩	◩									
	Ion Mass Spectrometer (1)	D											
SPACECRAFT SUBSYSTEM	Battery Packs	E				C							
	Command Receiver	F	◩										
	Tracking Transmitter	G											
	PCM Telemetry	H									⊠ ◩		
	Antenna	I											
	Solar Cell - Battery Charge	J				C							
	Program and Control	K				R							
	Tape Recorder	L	◩	M									
	Optical Aspect	M				◫ C							
	Thermistor-Pressure Monitor	N				R							
	Safety Monitor	O											
	Leak Valve	P											
	Magnetic Attitude Control	Q											■ C
	Nutation Damper	R											
	H2 Recombination Cells	S				C							
		T											

CODE

E - Facility Induced Problem
■ - Failure
◩ - Questionable Operation
⊟ - Marginal Operation
⊠ - Procedural Failure
◫ - Special Problem
R - Subsystem Repaired
C - Subsystem Changed
M - Subsystem Modified
D - Subsystem Redesigned
N - Subsystem Not Under Test
S - Special Operating Condition for Test

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AE-B Flight Spacecraft Test Performance Summary
December 6, 1965 to April 8, 1966

Line Item	Comments
A-29 (◪C)	Electron temperature probe No. 2 exhibited electrical leakage at feed-through after application of Loc-tite to improve seal. Flange/feed-through was replaced.
B-6 (◫)	After the first lateral axis vibration test, the equatorial neutral particle mass spectrometer did not function properly. After completion of the test, the equatorial mass spectrometer data indicated further degradation. Subsequent checkouts indicated that foreign particles shorted a rail section to ground. Repeated high-voltage flash treatments apparently burned out foreign particles and restored near-nominal performance. A slight shift in voltage was noted.
B-8 (■C)	The equatorial neutral particle mass spectrometer emission regulator was replaced. Failure analysis conducted. Transistor failed.
B-10 (◪)	Neutral particle mass spectrometer data were noisy at -10°C due to the pressure build up in the equatorial spectrometer tube. Also, there was a pressure build up in upper neutral particle mass spectrometer at about 3°C. Equatorial NPMS developed an external leak in the break-off mechanism feed-through. The upper NPMS developed an internal leak in the hatch cover seal. The high voltage connector on equatorial vac-ion pump loosened, and arcing noted.
B-11 (R)	Both NPMS's were evacuated and resealed.
B-14 (◪ ◫)	The filament in the equatorial neutral particle mass spectrometer was apparently damaged. It was later noted that the harness wire was broken, and an internal short existed. The vac-ion pump high voltage converter (not a flight item) for the upper neutral particle mass spectrometer failed (transistor).

Line Item	Comments
B-22 (N)	The ENPMS was not under test.
B-25 (CR)	The ENPMS experiment was replaced and the broken harness wire was repaired. Resistor replaced in UNPMS electronics package.
C-16 (C)	The NRC pressure gage was replaced.
C-22 and C-23 (◪) (◪)	The NRC pressure gage did not function when it was commanded.
E-2 (■ NC)	An inspection inside the spacecraft revealed that one HR-40 battery was leaking KOH. The leaking cell and five other HR-40 cells in the same battery pack were replaced.
E-25 (C)	The flight batteries were installed.
F-9 (◪)	Command receiver no. 2 did not respond to command no. 26. (Q-11).
F-22 (◪)	Some difficulty was experienced in commanding the safety monitor from building 14, executing command nos. 26 and 28 (magnetic attitude control subsystem), and, at times, with some other commands.
G-10 (◫)	The tracking transmitter was turned on by spurious signals.
H-8 (M)	A minor modification was made in both telemetry transmitters to reduce interference with the command receivers. The modification consisted of removing two capacitors and adding a third capacitor. Subsequently, both telemetry transmitters successfully completed vibration and temperature tests.

Line Item	Comments
H-10 (◪)	Extra pulse was noted from one encoder clock to tape recorder. An increase was noted in the resistance of the thermistors in both flight encoders, and also for the flight spare encoders.
H-11 (M)	Encoder harness wiring modifications were made. These consisted of adding five redundant wires to the encoder harness.
H-30 (◫ ◪)	Telemetry transmitter no. 1 connector was noted to be disconnected after the vibration test. Also, four connector retaining clips and screws were found in the bottom of the spacecraft after the test. The thermistor channel in encoder no. 2 appeared to have a faulty gate which indicated a high resistance and, consequently, a lower voltage reading.
J-25 (C)	One broken solar cell was replaced.
K-10 (◪ C ◫)	At 45°C the potting in the experiment selector and calibration card was noted to be soft in certain areas. The turn-on counter jumped seven counts at -10°C or while the spacecraft temperature was decreasing from 45°C to -10°C. The flight and flight spare counters also jumped by two's at 45°C.
K-11 (RM)	The experiment selector and calibration card were partially repotted. The turn-on counter was modified. The modification consisted of changing one capacitor and adding one resistor. Subsequently, the turn-on counter successfully completed the vibration test.
K-14 (◪ I)	Two wiring errors in the external spacecraft plugs (not flight items) precluded firing of the pyrotechnics. The plugs were subsequently repaired. A thin coating of sulfinated lard oil was deposited on the metal surfaces of the shell after the 0° aspect test. The source of oil was the yo-yo despin cables which were subsequently cleaned.

Line Item	Comments
K-15 (◪)	During the despin test, the yo-yo squibs did not fire as planned. The despin was achieved via the programmer after 170 seconds.
K-17 (◪)	Turn-on counter missed several counts. The pressure gages did not calibrate via the 170 second timer. The problem was attributed to the experiment selector and calibration card.
K-18 (M)	Modifications were made in the following cards: experiment selector and calibration card, pyrotechnics control card, and turn-on counter.
K-25 (R)	Broken pyrotechnics despin cable was repaired.
L-10 (◪)	The tape recorder did not function properly at -10°C and 45°C and also the flight spare recorder at -10°C. Excessive wow and flutter were noted.
L-11 (R)	The tape recorders were repaired: the tape was replaced on the flight transport; and the bearings, drive belt, and shimmed capstans were replaced on the spare transport.
L-14, L-17 and L-19 (◪)	The playback data from the tape recorder continued to be noisy.
L-20 and L-22 (M◪) (◪)	The modified tape recorder data continued to be noisy.
L-23 (M)	The modifed tape recorder successfully completed the sub-assembly tests, was installed in the spacecraft, and was checked out satisfactorily at -10°C and 45°C.
M-25 (■C)	The optical aspect earth sensor leaked and was replaced.

Line Item	Comments
N-8 (C)	Three thermistors were replaced.
N-9 (■)	One thermistor failed.
N-11 (C)	One thermistor was replaced.
N-25 (R)	A broken thermistor cable was repaired.
O-6 (◫)	After completion of the vibration test, it was not possible to command via telemetry the stepper switch in the safety monitor subsystem. After the two connectors were de-mated and re-mated, the problem disappeared. Both connectors successfully passed a pin retention test.
Q-10 (◪)	The magnetic attitude control subsystem did not function properly at -10°C. The subsystem turned on in the manual mode, but cut off after a few seconds of operation. It did not function in the automatic mode. The catch-all card was replaced with a flight spare; and subsequently, the subsystem functioned properly.
(Q-11) (R)	The electronics package was repaired, and the command 26 B gate diode was reversed. No additional subassembly tests were conducted.
Q-32 (■ C)	The Y-axis electromagnet did not function properly and was replaced. A failure analysis was conducted which indicated that an internal wire was broken.
S-25 (C)	Three flight fuel cells were installed.

5. SUMMARY OF SPACECRAFT OPERATIONS AT ETR

5.1 Pre-launch Operations

The flight spacecraft was shipped from GSFC April 11, 1966, by an air-ride van and arrived at ETR April 13, 1966. Preliminary abbreviated spacecraft checkouts were satisfactorily completed April 14, and on April 15 a harness wiring change, planned before shipment, was performed. An electrical grounding wire was routed from both electron temperature probe connectors to the shell rim. On April 18 satisfactory checkouts were conducted on experiments, magnetic attitude and spin rate control subsystem, and solar array.

On the night of April 18, while placing the protective plastic shell on the spacecraft, a small trim magnet on the exterior of the spacecraft was accidentally broken. The broken piece of magnet (2.7 gms) was left off the spacecraft and in effect reduced the spin axis dipole moment from -2980 to -3300 pole-cm. Since the actual desired dipole moment was -3300 pole-cm, no corrective action was required.

On April 19, the resistance in the equatorial neutral particle mass spectrometer feed-thru was noted to be high, and a gold clip was installed to give better contact and decrease the resistance. A set of spacecraft ordnance was successfully fired April 19, and on April 20 a full spacecraft electrical checkout was satisfactorily conducted. The flight pyrotechnics were X-rayed April 20-21 and on April 21-22 the solar array was cleaned.

The prototype spacecraft successfully completed a fit check with the flight shroud and a dummy third stage April 22. The clearance from the upper NPMS vac-ion pump to the inner section of the shroud was 1.4 inches. The assembly was then transported to pad 17B and mated to the first two stages of the Delta vehicle. On April 26 vehicle and prototype spacecraft RFI checks were successfully completed, and on April 27 the prototype spacecraft was returned to Hangar AE for storage.

Flight spacecraft checkouts were continued on April 25. The pressure relief valve was satisfactorily opened and closed; this was confirmed by leak tests and data printouts.

Final internal spacecraft mechanical and electrical preparations were performed April 26, and all internal ordnance was installed. A spacecraft checkout after lid closure indicated a problem with the equatorial NPMS and with the upper NPMS to a lesser degree. Hot air was applied to both NPMS amplifiers to drive out accumulated moisture which apparently caused the problem. The spacecraft lid was then closed and sealed.

On April 27 the spacecraft successfully completed leak tests which included cup checks as well as a total leak rate test in a portable vacuum chamber. The resulting total leak rate was 1.39×10^{-7} atm. cc/sec. Several spacecraft ports were subsequently leak tested, and the earth sensor leak rate was found to be 3.2×10^{-7} atm. cc/sec. which essentially accounted for all of the spacecraft leak rate. The earth sensor seal had apparently degraded by about two decades since installation in March. Spacecraft electrical checkouts were conducted immediately after the leak tests with helium still in the spacecraft. In the resulting data printouts, some spikes were noted in the NPMS and pressure gage data. After the spacecraft was purged with nitrogen it was noted that the spikes disappeared.

On April 28 a gross leak was detected around the left lens of the earth sensor. The lens seal had deteriorated so badly that the lens noticeably bulged outward. The earth sensor and harness connector were removed from the spacecraft, and on April 29 a blank plate was installed in the shell to seal the port. The spacecraft balance was preserved by machining the blank plate to the proper weight.

Measurements were made April 28-29 of the spacecraft receiver sensitivity which indicated a possible problem with the no. 2 telemetry transmitter. On April 30 the spacecraft was moved to the antenna range where satisfactory receiver sensitivity measurements and antenna pattern checks were made. The previous difficulty with the sensitivity measurements was attributed to electrical check-out equipment and not the spacecraft. The spacecraft was resealed and leak tested April 30; the total leak rate was 7.9×10^{-9} atm. cc/sec.

An additional spacecraft checkout was satisfactorily completed May 2 after which the spacecraft was delivered to Douglas Aircraft Company for spin-balance with the FW-4 third stage. The spin-balance operation was successfully performed from May 2-5 and on May 4, the spacecraft was temporarily de-mounted, and the igniter in the third stage was replaced (igniter X-rays indicated a minute internal crack). On May 5 a thorough investigation was made by all personnel concerned to identify an unknown noise heard in the spin-balance bay. Although the investigation resulted in several noise source possibilities, the source could not be positively identified.

The spacecraft/third stage assembly was transported to pad 17B and erected on the first two stages on May 6, and an all systems test-vehicle and spacecraft-was successfully conducted May 6. On May 7 a satisfactory spacecraft checkout and satisfactory receiver sensitivity measurement were made, and the exterior of the spacecraft and pressure gages were cleaned.

F-1 day, scheduled for May 9, slipped to May 10. The spacecraft was commanded on the night of May 10 with helium in the spacecraft, and spikes were again noted in the NPMS and pressure gage data. Subsequent spacecraft purging with nitrogen apparently caused the spikes in the data to disappear.

On the night of May 10, one of four antenna feed-thrus in the spacecraft was accidentally broken. The spacecraft was returned to Hangar AE May 11, and the damaged antenna feed-thru was replaced. On May 12 a satisfactory spacecraft checkout was conducted, the internal ordnance was re-installed, and the spacecraft was re-sealed and leak tested; the total leak rate was 4.5×10^{-8} atm. cc/sec. The spacecraft was then transported to pad 17B and re-mated to the vehicle. A satisfactory spacecraft checkout was conducted, external ordnance was installed, and the spacecraft shell was spot cleaned.

On May 13 the AE-B launch was postponed to May 24 because of higher priority Nimbus and Gemini launches. From May 14-23 daily spacecraft checkouts were satisfactorily conducted, the spacecraft was purged twice daily with nitrogen, and spacecraft safety monitor checks were made very 6 hours (purging and safety monitor checks were routine procedure at ETR whenever the spacecraft was sealed). On May 19 another all systems test — vehicle and spacecraft — was satisfactorily conducted.

Electrical vehicle checks on May 23 resulted in a burned out resistor in the spin table spin rocket circuitry. Repairs necessitated a one-day delay in launching.

F-1 day was May 24, and a satisfactory spacecraft checkout was conducted prior to beginning final preparations. Final spacecraft preparations included: spacecraft cleaning, installation of antennas and ETP probes, arming of external ordnance, final leak (cup) tests, spacecraft pressurization to 7.4 psig with nitrogen, and final inspection and photographs. After fairing installation, the spacecraft was commanded on to ensure command capability and to verify that the pyrotechnics bus was disabled. The turn-on data indicated that the tape recorder clock was operating and that the spacecraft had been commanded on by spurious signals. Another command was sent to stop the clock which was verified by a subsequent command.

5.2 Launch

F-0 day was May 25, 1966. During the countdown, which proceeded smoothly, the spacecraft was commanded on periodically to confirm launch readiness. Liftoff occurred as planned at 0900 EST. Launch events appeared normal except for an overburn of approximately 8 seconds by the vehicle second stage. Because of the overburn the apogee achieved was significantly higher than planned. The principal orbital elements achieved as compared to planned were:

Orbital elements	Achieved	Planned
Apogee, km	2,725	1,205
Perigee, km	278	270
Inclination, degs.	65°	64°
Period, mins.	116	99

6. ORBITAL PERFORMANCE

The AE-B spacecraft was officially renamed Explorer 32 upon achieving orbit. After orbital injection, spacecraft events proceeded as planned. Yo-Yo despin to 30 rpm occurred on command as well as firing of explosives and separation of all break-off mechanisms. Early orbital turn-ons of the spacecraft yielded high quality data and indicated that all experiments and spacecraft subsystems were functioning normally.

On the fourth day in orbit the logic electronics in the upper neutral particle mass spectrometer began to malfunction. On the eighth day the logic electronics in the equatorial neutral particle mass spectrometer began to function improperly. Both NPMS's exhibited similar malfunctioning modes; the logic electronics were locked in a particular operating sequence.

In an effort to determine the cause of failure an investigation was conducted by project personnel. The results of the investigation indicated that although vibration, radiation, and pressure may have been possible causes of the malfunctions, subsequent tests in each of these areas yielded negative results; all tests were successfully completed. Further study indicated that a particular capacitor in each logic electronics may have degraded to the point of failure.

During 100 percent sunlight near mid-August the tape recorder began to malfunction. Although the tape recorder continues to operate, the playback data exhibit excessive noise. An investigation by project personnel, although not definitely conclusive, indicated that the malfunction may be attributed to the tape recorder clock strobe electronics.

According to telemetry data, the maximum temperature the tape recorder attained during 100 percent sunlight was 42°C. A temperature test (45°C for several days) was conducted on the spare tape recorder and converter/drive motor subassembly, but revealed no indication as to the cause of the malfunction. Since the temperature test was successfully completed, it suggests that temperature per se may not have caused the malfunction.

Other than the two problem areas discussed, Explorer 32 continues to perform well. The total number of spacecraft turn-ons in orbit as of September 22, 1966 was 3380 which includes 430 tape recorder playbacks.

7. CONCLUSIONS

Spacecraft performance thus far has resulted in obtaining excellent data throughout a full diurnal cycle, the orbital plane having precessed more than one full rotation.

The major objectives of the spacecraft have been achieved except as limited by the neutral particle mass spectrometer failure. In this respect, the neutral particle mass spectrometer experiment was partially successful in that approximately 100 turn-ons were obtained which yielded high quality data and provided new information concerning the latitudinal variation of atmospheric composition.

The tape recorder malfunction after 430 turn-ons, although a failure, has not affected the real time capability of the spacecraft which continues to perform well. In fact, the lack of tape recorder usage has permitted a 50% increase in the number of real-time turn-ons. An effort is currently being directed towards exploring more sophisticated methods of data processing which may render additional tape recorder data useful.

Approximately four months of orbital lifetime have elapsed and Explorer 32 has achieved most of its objectives. The spacecraft and the test and evaluation program are therefore considered to be successful except as limited by the partial success of the neutral particle mass spectrometer experiment.

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